

XVI.—On the Pelvic Fins in the Postlarval and Young Stages of *Onus mustela* (the Five-bearded Rockling). By DAVID M. PAUL, Gatty Marine Laboratory, St. Andrews.

[Plate V.]

THE young of this form has at different times and by different observers been described as a distinct species, principally on account of the great development of the pelvic fins and the difference in coloration from the adult. The young fish was first described by Couch* under the name of "*Ciliata glauca*," the generic name being given on account of the peculiar character of the first dorsal fin. The name "*Ciliata*," however, was already occupied, and Thompson† proposed the name "*Couchia*," and this was the term used by Günther in his 'Catalogue of Fishes in the British Museum'‡. It was pointed out by Malm, and soon afterwards by Lütken§, that this was not a distinct species, but merely the young stage of the rockling. In popular language the young fishes are known as the "mackerel midges," because they afford food to large numbers of mackerel and other fishes which follow and prey upon them as they swim in shoals. A similar, if not identical, form was described by Agassiz||, and its early development studied by him and Whitman¶. The early development has been studied in this country by Brook**, who also gives a short note on the postlarval stages of the allied species *O. cimbria*. In this paper he gives a table showing the sizes of the fish and of its fins at different stages. The postlarval and young stages were also described by M'Intosh†† and Prince‡‡, and the former has also a paper§§ in which he studies in greater detail the later stages in the growth of this species. In all these papers, however, the later development of the pelvic fins has only been touched upon, and more attention has been paid to the changes in size and external appearance than to the structure and function of these fins at different stages in the life-history of the fish.

* Loudon's Mag. Nat. Hist. vol. v. pp. 15 & 741.

† Nat. Hist. Ireland, vol. iv. p. 190.

‡ Vol. iv. p. 363.

§ Smitt, 'Scandinavian Fishes,' pt. i. p. 544.

|| Proc. Amer. Acad. Sci. & Art, vol. xvii. (1882).

¶ *Ibid.* vol. xx. (1884).

** Linn. Soc. Journ., Zool. xviii.

†† Proc. Roy. Physical Soc. Edinb. vol. x.

‡‡ Trans. Roy. Soc. Edinb. xxxv. p. 832.

§§ Scot. Fish. Board Rep. 1896, p. 203.

The present paper is an attempt to give a somewhat more detailed account of this latter part of the subject.

In their young stages many fishes have greatly developed paired fins, while in the adult these are less in proportion. In some cases it is the pectoral fins which are thus hypertrophied, while in other cases it is the pelvic fins. The young gurnards, for example—both the red and grey species—have large pectoral fins, while in the ling the young has huge pelvic fins which become reduced in proportion as the fish grows. In the various species of rockling it is always the pelvic fins which are thus enlarged. The following table gives the length of the body and that of the pelvic fin at various stages; the figures are only what may be called the mean measurements, different specimens varying greatly in the development of the fins. The measurements are all expressed in millimetres, and apply only to spirit-specimens.

Size of fish.	Size of fin.
mm.	mm.
4.8	1.8
5.5-6.8	2.0
7-8.5	2.5
9-11.5	2.8
11.5-14.5	3.5
16-18.5	4.5
20-25.5	4.1
26	4.2
27-29	4.3

As has been already stated, this development is subject to considerable variation: for example, of two specimens each measuring 11.5 millim. the pelvic fins measured 2.8 and 3.1 millim. That with the longer fin was captured in August and that with the shorter fin in May; but as the rockling spawns from March to December this proves nothing. The condition of the other fins, however, points to the conclusion that the fish with the longer fin was slightly older than the other. The table indicates that the growth of the pelvics is at first extremely rapid, but a point is reached at which an actual reduction in size of the fin takes place. Like all the rest of the development, this feature is extremely variable, but the mean may be taken to lie between 20 and 25 millim., although we may get specimens of 17 millim. whose fins have undoubtedly passed this critical point. Several specimens over 25 millim. have been examined whose fins show no signs of reduction. About this time a change comes over the habits of the fish. It has hitherto been pelagic, but now it

betakes itself to the rock-pools and its bluish-green back and silvery sides give place to the uniform brown coloration of the adult.

The fin may now be described at several stages in more detail. In the earliest stage obtained the fish measured slightly less than 5 millim. The fin (of which Pl. V. fig. 1 is a drawing) extends a considerable distance behind the anus; it measures 1.8 millim., *i. e.* rather more than one third of the total length of the fish. The fin-rays are four in number and are of equal length. At the tips they tend to become split up into a number of fine filaments. The pigment in this particular specimen was small in amount and confined to the tip of the fin, the remainder being yellowish. At this stage the pectoral fin is about one third the size of the pelvic and is fan-shaped. The base of the pelvic fin is only very slightly in front of the pectoral at this stage, thereby contrasting with its situation in the adult, where it is considerably in front. This shows that, as in other species, the tendency of the pelvic fins is to shift forward. The epithelium, as shown in transverse section, is thin and undifferentiated; it is not wrinkled between the fin-rays, as in somewhat older specimens, showing that the fin cannot be spread in the form of a fan, as in later stages. The pigment varies greatly in different fins at the same stage; this may be due to individual variation, but more probably because all the specimens examined had been preserved in spirit, some for a considerable number of years. As the young fish grows the pelvic fins increase in length, but still keep the same form. The black pigment becomes more and more confined to the tip of the fin, so that when the fish is 10-12 millim. long the extreme tip of the fin alone is deep black, while the rest is pale in colour. At this stage the fin measures about one fourth of the total length.

Fig. 2 (Pl. V.) represents the fin of a young rockling which was still pelagic, although it had grown to a size of 20 millim. The tips of the fin-rays are not now split, though they are still very long. The number of fin-rays has increased to six, and of these the second is slightly the longer, while the fifth and sixth are short. Sections near the base of the fin at this stage show that it differs from the adult only by the less highly differentiated epithelium. Between the fin-rays the epithelium is now much folded, so that the fin can be spread out like a fan. This is connected with the fact that the fish leads a pelagic life and seeks its food near the surface, the fin being used mainly, if not wholly, as a locomotor organ, while in adult life it is used chiefly as a tactile organ.

As the fish grows beyond this stage the tips of the fin-rays are absorbed, and it is this which gives rise to the shortening of the fin (fig. 3). A transverse section through the anterior portion of the fin is represented in fig. 5, four fin-rays being cut. In this specimen the pigment is very well developed, a complete layer of pigment-cells being present on the side which is directed outwards. The bundles of nerve-fibres are also shown in the section, as well as the undifferentiated character of the epithelium. In the next stage gradual differentiation of the epithelium takes place, accompanied by absorption of the membrane between the first and second and the second and third fin-rays. This is most noticeable in the case of that between the first and second fin-rays. When this process is finished the first ray is free for about one third of its length and the second ray projects about the same distance beyond the tip of the first. The fin-rays themselves become thicker and the extremities are provided with sensory organs. The pigment of the tips, which was so marked in previous stages, is now reduced to a few cells of the usual stellate type (fig. 4). At this stage the free tips are much longer in proportion than in the adult, but as the fish grows the fin becomes deeper and soon acquires the proportions characteristic of the adult.

Adult fin.—Fig. 6 (Pl. V.) represents the fin of a rockling of 98 millim. which was obtained below stones in a rock-pool at St. Andrews. At this stage the fish has all the characters of the larger-sized adults. The fin-rays, of which there were seven, vary in different cases from seven to nine. The former number is more usual, the latter having been only found in one specimen. The last two or three rays are very short. The first is separated from the second, which is the longest, for a considerable distance. Over the surface of the fin are scattered small brown pigment-cells, while near the base occur larger black chromatophores which are visible as small black dots when the fin is viewed through a lens. In transverse section (fig. 7) the following structure is shown:—Centrally are five pairs of dermal fin-rays (*dr.*), above and below each of which lie a pair of nerve-cords (only five pairs of fin-rays are shown, as the section is taken about the middle of the fin, and so does not cut fin-rays 6 and 7). The nerve-cords give off branches to supply the sense-organs, dividing as they proceed towards the tips of the rays, which are more richly innervated than the rest of the fin on account of the greater number of sensory bodies there. The rest of the space is filled up with loose connective tissue in which ramify small blood-vessels. The epithelium consists

of the following layers (fig. 9):—Externally is the cuticle, which is composed of small compressed cells. Next is the Malpighian layer, which is composed of long columnar cells having a peculiar beaded appearance, more conspicuous in certain sections than in others. This epithelium is very similar to that on the free rays of the pectoral arch of the gurnard*, and seems to be highly specialized for the purpose of conveying tactile impressions. Below lies the corium, a homogeneous layer without any obvious cellular structure. Beneath this, again, is a layer of fine nerve-fibrils, which supply the sensory organs. A transverse section of a free ray (fig. 8) exhibits the same structure, except that the sense-organs are more numerous and the nerve-supply more highly developed than in the body of the fin. This points to the explanation that the free tips of the fin are mainly used in searching for food, and this is corroborated by actual observation of the living fish.

The sensory organs (fig. 10) have already been described and figured by Bateson † in large numbers of other fishes as well as in the rockling:—"They consist essentially of clusters of long cells arranged together to form a bulb-shaped body, whose apex is not covered by cuticle, but projects upon the surface of the skin." In the rockling the base of the bulb is in contact with the basement-membrane, and through this the nerve enters. In certain other fishes the skin is channelled to receive the nerve. These organs occur in *Onus mustela* on all the barbels, on the pelvic fins, and also on the pectoral fins, on which latter place Bateson does not appear to have noticed them. In the young stages these organs are absent, while in the adult, although they are most numerous at the tips, they occur all over the body of the fin, especially on the first fin-ray. This is connected with a change of habitat, for while the young form is pelagic, the adult lives below stones and in chinks in runlets, and seeks its food at night by feeling along the bottom with its fins spread out at right angles to the body as it swims along. It is possible that these structures may be more than tactile; they may be used for tasting, since when the rockling touches anything in the tank with its fins it seems to be able to distinguish between food-substances and others. For example, Bateson noticed that when a rockling touched a piece of glass or stone smeared with vaseline it turned and examined it, "clearly remarking the peculiar feel of such substances." The rockling

* H. C. Williamson, Scot. Fish. Board Rep. 1893.

† Journ. Mar. Biol. Assoc. 1889-90, p. 225.

usually hunts by smell and not by sight, and when food is put into the tank it does not swim straight towards it, as many other fishes (*e. g.*, cod) do, but rushes wildly about with its pelvic fins spread out at right angles to the body until it brushes against it. The evidence, however, is not sufficient to decide whether these organs are purely tactile or whether they are used in the same way as similar structures in the higher vertebrates.

My best thanks are due to Professor McIntosh for his kindness in supplying material and for many helpful suggestions.

EXPLANATION OF PLATE V.

- Fig.* 1. Left pelvic fin of *Onus mustela*, 5 millim. in length.
Fig. 2. Ditto, 20 millim. in length.
Fig. 3. Ditto, 23 millim. in length.
Fig. 4. Ditto, 32 millim. in length.
Fig. 5. Transverse section of pelvic fin of *Onus*, 23 millim. in length.
ep., epithelium; *fr.*, dermal fin-rays; *n.c.*, nerve-cord; *pg.*, pigment.
Fig. 6. Pelvic fin of a specimen 98 millim. in length.
Fig. 7. Transverse section of the foregoing.
Fig. 8. Free ray of ditto in section, more highly magnified.
Fig. 9. Epithelium of ditto, high power.
Fig. 10. Sense-organ.

Figs. 1, 2, 3, 4, and 6 are not drawn to scale. The actual size of these is represented by the line underneath each.

Reference letters.

<i>bs.</i> = basement membrane.	<i>mp.</i> = Malpighian layer.
<i>ct.</i> = cuticle.	<i>n.c.</i> = nerve-cord.
<i>dr.</i> = dermal fin-ray.	<i>s.o.</i> = sense-organ.
<i>ep.</i> = epithelium.	<i>t.</i> = connective tissue.

XVII.—*Notes and Descriptions of some Dynastidæ from Tropical America, chiefly supplementary to the 'Biologia Centrali-Americana.'* By GILBERT J. ARROW, F.E.S.

I.—*On Central-American Species of the Genus Cyclocephala.*

ALTHOUGH thirty-five described species of *Cyclocephala* are enumerated by H. W. Bates in the 'Biologia Centrali-Americana,' this probably forms scarcely more than a fraction of those actually inhabiting Central America. The British Museum collection already contains about a dozen additional species, and, as certain corrections have to be made to the